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National Ignition Campaign (NIC) Hohlraums Part 2b: Improved Modeling

Presentation to
NIC Science of Ignition Webinar Tutorial Series
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If HFM is so grand, why is V_{imp} lower than expected?

- Dante radiant intensity (W/sr) = $T_R(t)^4$ x $A_{LEH}(t)$
  - — Simulations match Dante but appear to have T_R high and A_{LEH} low.
    - – T_R high : DCA is imperfect & it's hard to resolve the conversion layer
    - – A_{LEH} low : Hard to properly model LEH

- Including effects such as hohlraum wall's outward motion may change the answer

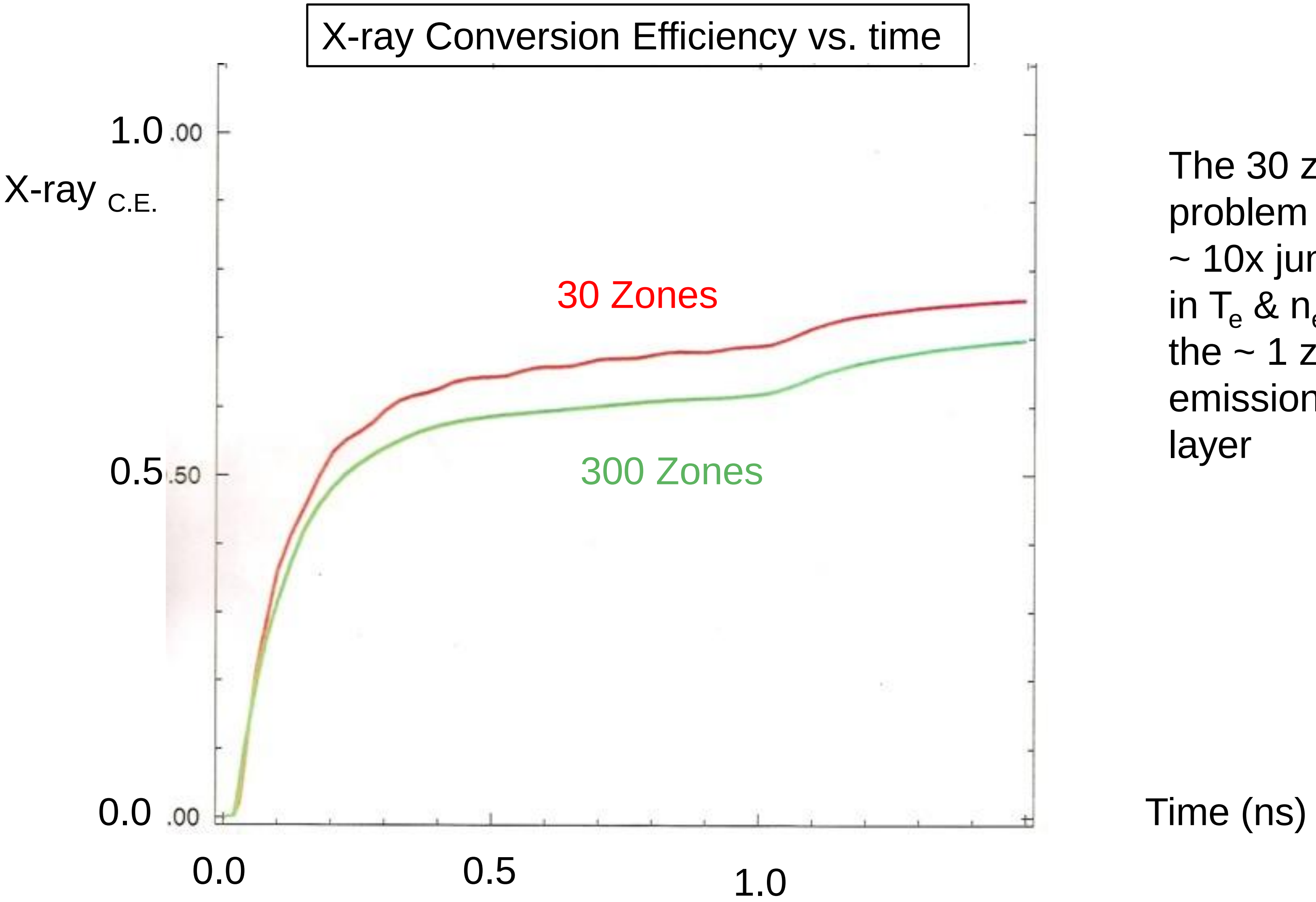
A better zoned model, that also allows for wall motion outward, (C. Thomas/R. Town) has recently been developed, & results in a larger A_{LEH} & lower T_R

- Internal LPI might re-distribute energy, and lower the drive
  - — Especially during rise of the main pulse?
  - — Hot electrons seem to have only a moderate effect on drive

- Gas-Au interface may mix, possibly partially block laser & lower drive

- Issues of how / when to switch from NLTE to LTE can also affect the answer
  - — But need DCA in LTE to match more sophisticated Table's LTE opacity

For the Omega Au sphere data, zoning matters



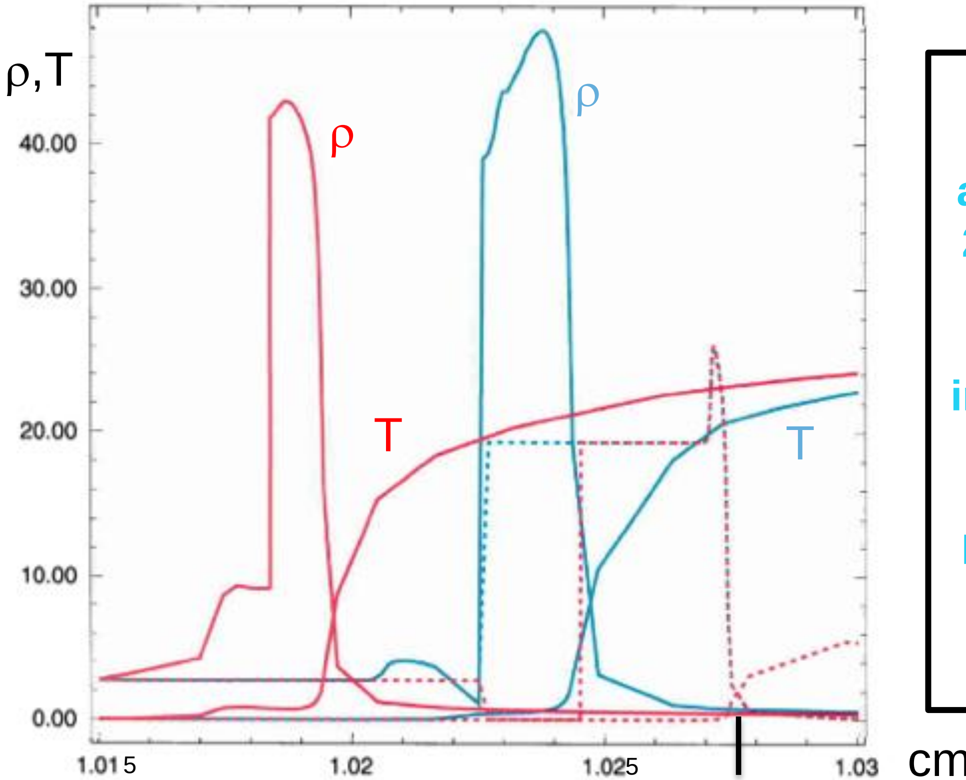
The 30 zone problem has ~ 10x jump in T_e & n_e in the ~ 1 zone emission layer

Hohlraum’s wall moves outward in time

Au Wall motion:

30 μ Au, 20 μ gap, 250 μ of Al

Modeled here in 1-D, driven from the right by $T_r(t)$



solid: t = 20 ns, dotted: t = 1 ns

Au wall (non)motion as modeled in 2-D hohlraum simulations: 50 μ Au immobilized at its back

Modeled here in 1-D, driven by $T_r(t)$

The Au wall moves ~ 80 μm ~ 8 x its (in-flight) width

Improvements to rad-hydro modeling methodology are in the works

- **We've begun using a more self consistent LPI package**
  - **Legislates where & how much SRS / SBS is created**
    - **sends their scattered light back through the plasma.**
  - **Can locally dump the SRS plasma wave energy into hot-electrons**

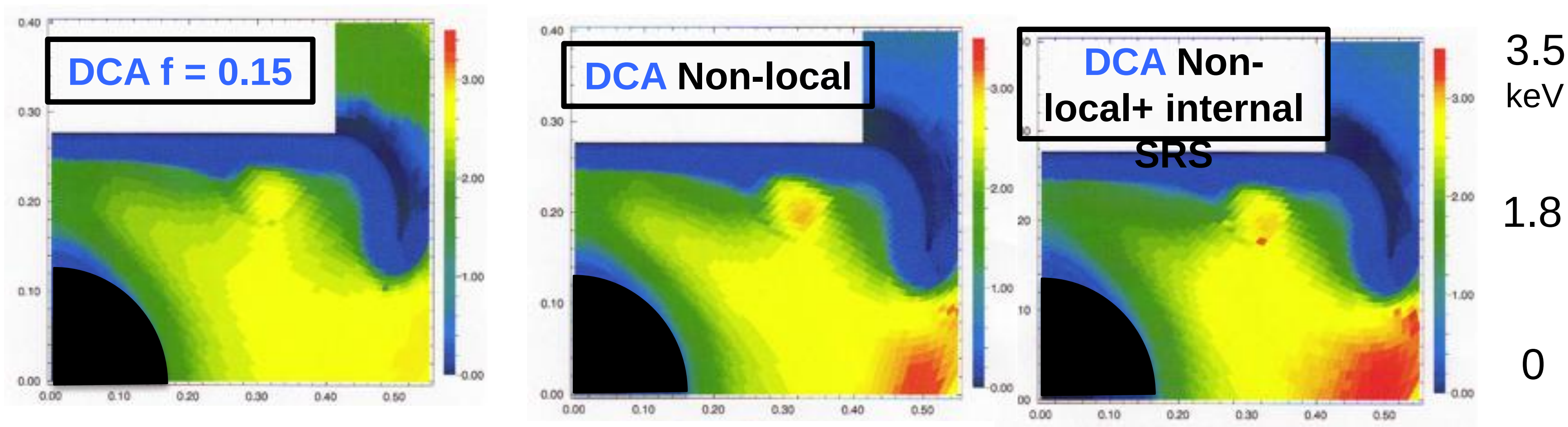
- **An in-line cross-beam transfer package is in the works**
  - **Will include ponder-motive forces that can change the plasma profile /matching conditions.**
  - **Needs to include kinetic ion heating.**

- **Gas-Gold interface mix is being assessed**

Besides better modeling, we need to do experiments that test these models

The plasma conditions at the LEH are sensitive to the level of sophistication of the HFM simulation

T_e (0-3.5 keV contours) in 1 MJ hohlraum at 18 ns (middle of main pulse)



All 3 simulations use the *incident* laser pulse

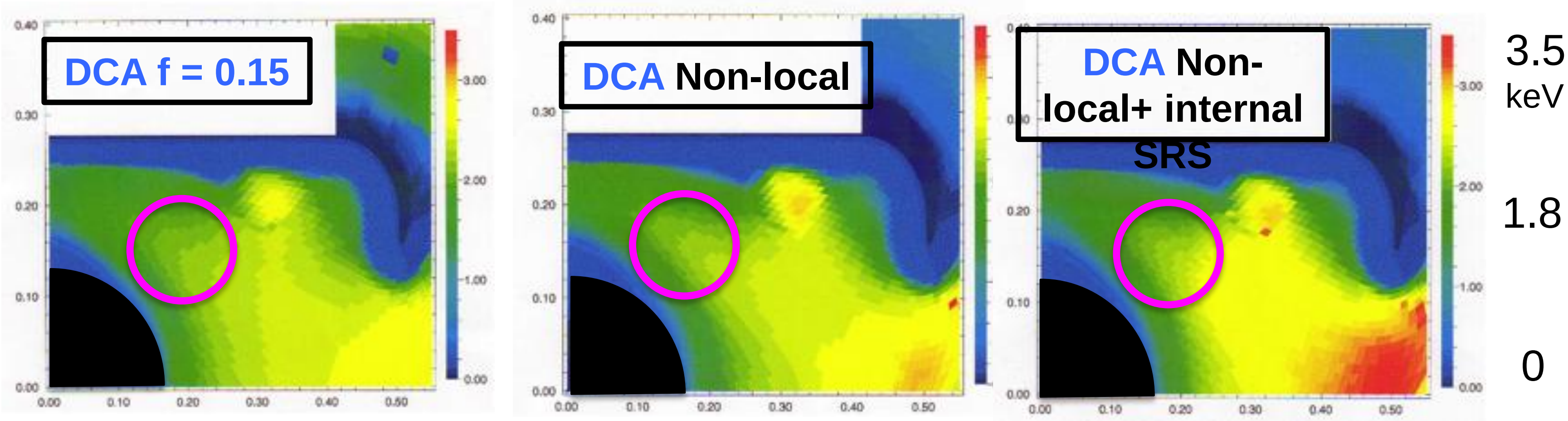
Plasma conditions at the LEH affect cross-beam transfer

This may be an example of SRS, after the rise of the main pulse, heating the LEH and lowering the amount of cross-beam transfer. An in-line SRS package *and* an in-line cross beam transfer package could, in tandem, capture this physics.

Kinetic effects can heat ions and also turn off the transfer- Michel, Rozmus, Divol, Berger, Williams

The plasma conditions at the interior, SRS site, are less sensitive to the exact choice of simulation HFM

T_e (0-3.5 keV contours) in 1 MJ hohlraum at 18 ns (middle of main pulse)



All 3 simulations use the incident laser pulse *with* SRS subtracted

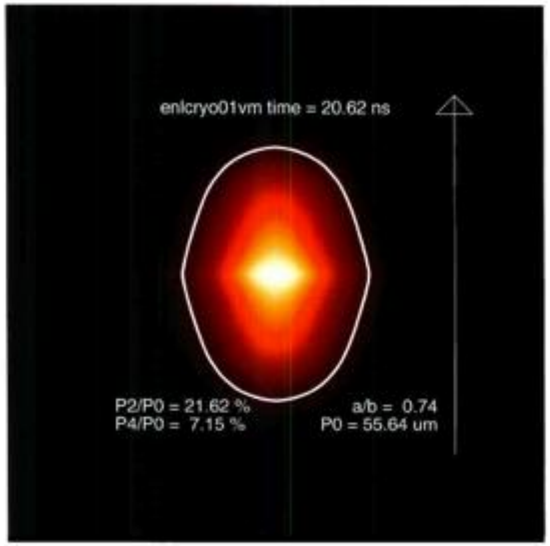
Plasma conditions at the SRS site affect level & spectrum of the SRS

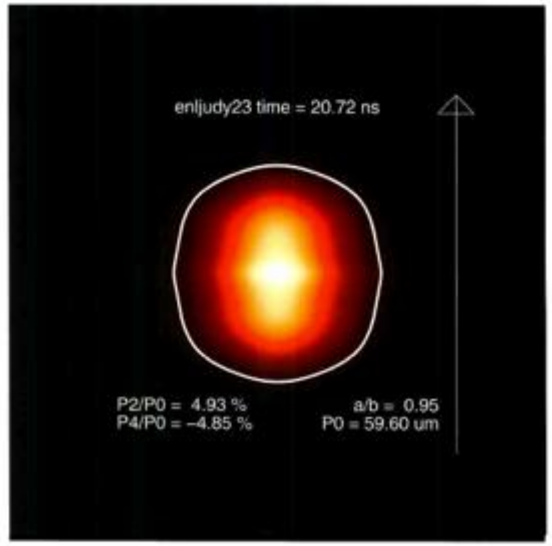
We are testing the package that produces hot-electrons from the SRS. These hot-e s can directly preheat the target, or indirectly through atomic physics excitation of higher frequency photons.

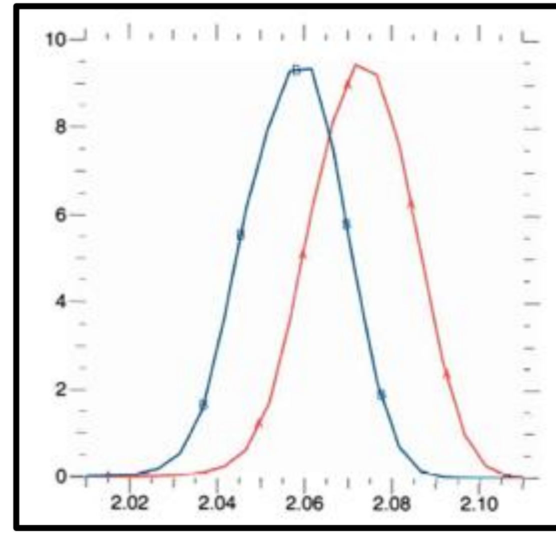
Currently, the package transports the hot-e s isotropically.

Internal reflection of the laser light can delay the "bang time" by ~ 150 psec

Standard	Internal reflection	X-ray Brightness (t)







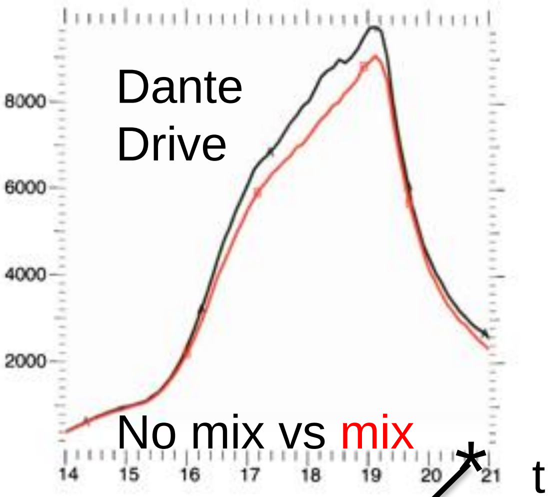
20.4 20.8 t (ns)

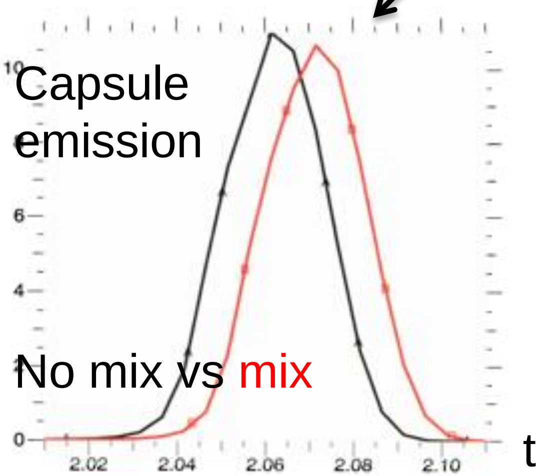
To get 150 psec delay: We deny the "waist" of the hohlraum laser light, by back reflecting 90% of it, (*<u>during main pulse rise</u>*) at longer λ (green) Raman back Scatter

This green light does not make it out of the hohlraum , "consistent" with observations

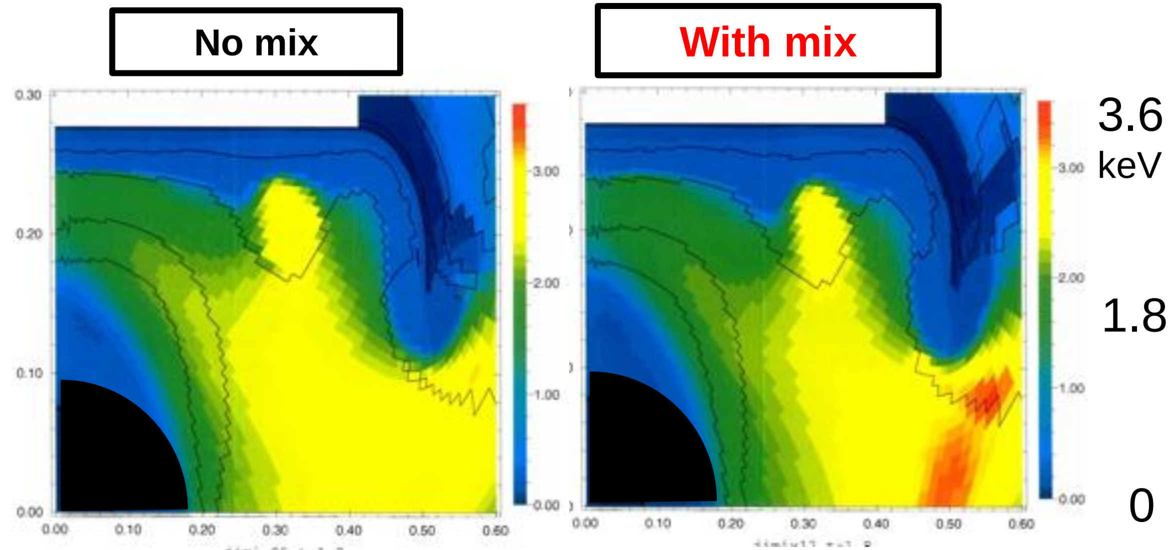
If this SRS made hot-electrons, we must invoke B fields to keep these hot-electrons from depositing in the Au walls & emitting bremsstrahlung

A sub-grid model of mixing of high Z with low Z in the hohlraum delays the drive and the implosion





T_e (0.- 3.6 keV contours) in 1 MJ hohlraum at 18 ns (in the main pulse)

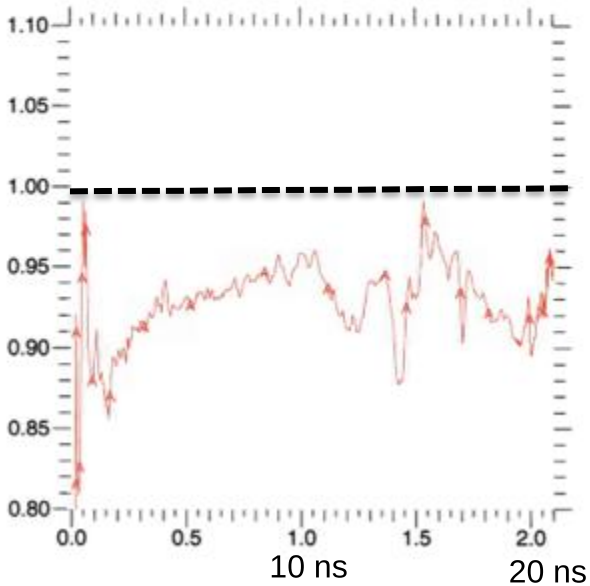


The mix simulation delayed capsule "bang time" by ~150 psec

D. Callahan pointed out sensitivity of the calculations to the choice of Te at which we switch to NLTE

Ratio of drive: Switch from LTE Table to NLTE DCA:@ T_e=T_r(t) vs. T_e=300 eV

$$\frac{T_R^4\ (\text{switch @ } T_e(t) = T_R(t))}{T_R^4\ (\text{switch @ } T_e = 300\text{ eV})}$$



T_r(t) switch from LTE table to NLTE DCA, delays "bang time" by ~ 200 psec

but: for T= 100-150 eV: LTE Table's Opacity > DCA's

The High Flux Model ("HFM") is now being used to describe NIC ignition scale hohlraums

The NIC '09 1 MJ hohlraum energetics campaign showed very good Coupling, Drive and Symmetry

But there were inconsistencies within each category

With a better physics model, and a deeper analysis of the data, we now have:

Better data consistency, due to a change in the predicted plasma conditions

The better physics model includes:

A Detailed Configuration Accounting (DCA) Atomic Physics Model
An improved electron conduction model

Other diagnostics (e.g. Thomson Scatter) should independently confirm this

The NIC has adopted a new ("Golden") aspect ratio hohlraum, based on the HFM, that has helped us achieve better symmetry at less $\Delta\lambda$.

We continue to upgrade our modeling capabilities

Improving our understanding of NLTE, LPI & Laser Propagation can bring us closer to ignition

The HFM has helped explain plasma conditions- but

We'd like direct measurements of T_e (Thomson Scatter, spectroscopy)

We'd like to find ways to make T_e hotter. (higher Z dopants, B fields,…)

Improvements in DCA could help us apply it even more universally

Avoid issues of when to switch to NLTE, Help with M – band optimization

Models of cross beam energy transfer (& its saturation) need to be implemented within the hydro code - and be tested by dedicated experiments

Understanding & implementing LPI saturation models would also be useful

Test these ideas on smaller facilities (laser methods- bandwidth, STUDs)

Try to mitigate LPI on NIF (less x-beam, SBS suppressing SRS, foams,...)

We should continue in efforts to bridge micro-scale to macro-scale

Computational Grand Challenge: LPI, interpenetrating plasmas, all B field terms

Improve in-line LPI package, to assess internal LPI effects

Assess hot electron effects on capsule and in hard x-ray production

With this improved understanding, we can lower losses and improve drive, learn to control symmetry and adiabat better, and thus bring us closer to ignition.


NIC